CHAPTER 8

PIPING SYSTEMS

8-1. General piping systems design

Policies, criteria, procedures, and responsibilities for operation, maintenance, repair, and construction of facilities and systems for the efficient and economical management of piping utility services shall be in accordance with Army Regulation (AR) 420-49, Utility Services. Figure 8-1 identifies commonly used symbols and abbreviations for the piping and instrumentation diagrams presented in this chapter.

a. Potable water will be supplied in accordance with the Safe Drinking Water Act (SDWA) of 1974 as amended in 19 June 1986 (PL 99-339) and in October 1988 by the Lead Contamination Control Act (PL 100-572) (42 U.S.C. 300f, et seq.) and all applicable state and local regulations. Installations that are Outside Continental United States (OCONUS) and classified as suppliers of water will comply with the standards in the National Primary Drinking Water Regulation and final governing standards issued by the Department of Defense (DOD) Executive Agent for the host nation concerned. The theater surgeon may approve OCONUS requests for deviation from the Continental United States (CONUS) drinking water standards.

b. Treatment of wastewater and non-point source (NPS) pollution control and abatement will comply with the applicable parts of the Clean Water Act (CWA), as amended (33 U.S.C. 1251, et seq.), AR 200-1, Environmental Protection and Enhancement, and AR 420-79, Natural Resources; Land, Forrest, and Wildlife Management. Measures for NPS pollution control will be included in all construction, installation operations, and land management plans and activities.

c. Consider possible future expansion when designing fluid systems. Any expansion plans for the systems or facilities shall be considered. In general, if expansions are planned, utilities should be extended to a point where connection can be made without damage or disruption to existing facilities.

d. Piping for areas planned to accommodate the physically handicapped shall be designed in accordance with the Code of Federal Regulations (CDR), 28 CFR 36, Americans with Disabilities Act (ADA).

e. All piping systems shall have the capability of being remotely controlled from the control room.

f. Upon a loss of normal electrical power, piping systems serving mission critical areas or systems shall be powered from the emergency generators. Piping equipment and systems whose loss of power would impact the facility mission (i.e., controls) will be operated from the uninterrupted power supply (UPS) system until the facility generators can restore power.

8-2. Piping systems reliability and survivability

Piping systems installed in Command, Control, Communications, Computer, Intelligence, Surveillance, and Reconnaissance (C4ISR) facilities shall meet the following reliability and survivability goals.

a. In mission critical facility applications, mechanical components, such as air compressor systems and mechanical pumps, shall have N + 2 redundancy, where N is the minimum number of units required and 2 is the required number of redundant units. If the mission is less critical, one extra unit (N + 1) may be adequate. Three factors dictate the level of redundancy required: (1) critical nature of the

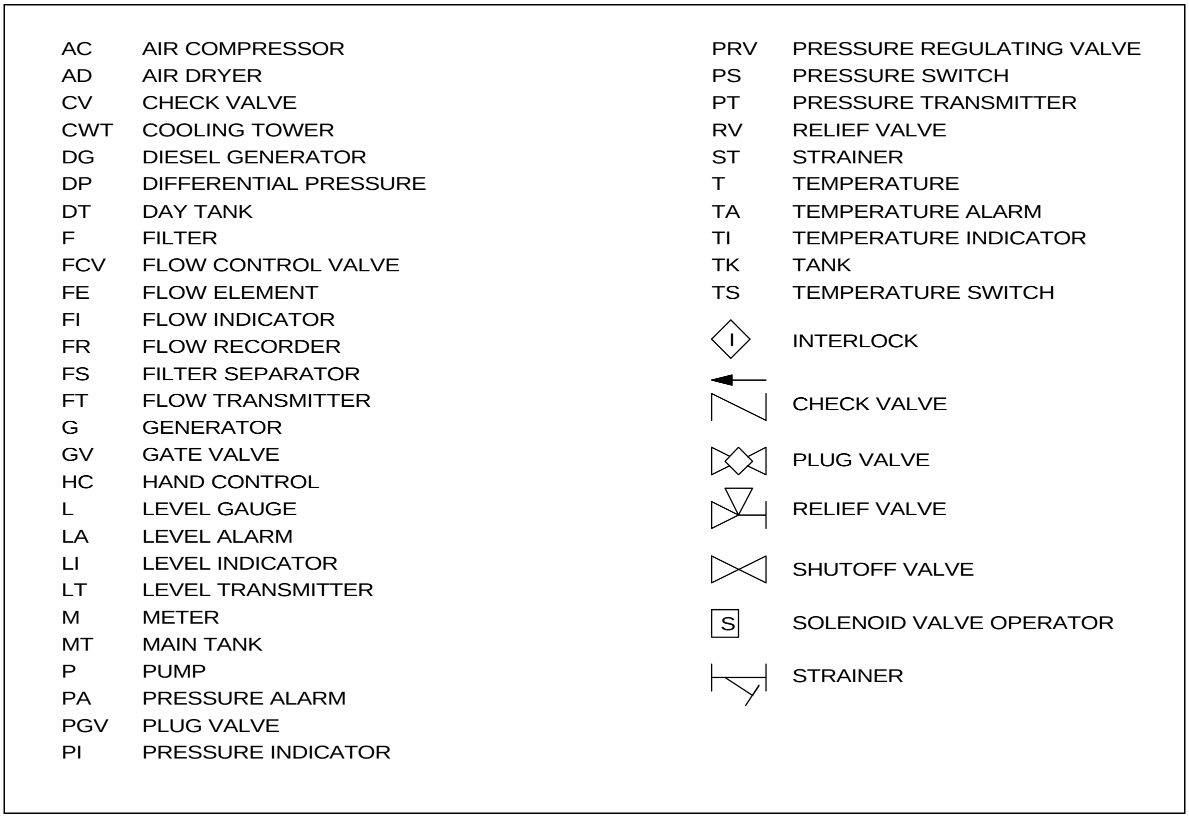

Figure 8-1. Piping and instrumentation diagram legend

mission, (2) equipment reliability, and (3) equipment cost. The authority having jurisdiction (AHJ) and the design engineer(s) shall assess these factors when determining the level of redundancy required for a specific C4ISR facility. Redundant units will be designed to automatically start and maintain the load should the operating unit fail. Due to the high degree of reliability required for computer cooling systems, redundant components on the control system(s) may be justified.

b. Piping systems installed in C4ISR facilities will be of such design or otherwise protected to withstand seismic effects as well as shock (ground motion) and overpressure effects of weapons. A detailed dynamic analysis will be made of the supporting structure(s) of the piping equipment to evaluate the magnitude of motion and acceleration established at the mounting points for each piece of equipment. Where accelerations exceed the allowable limit of equipment available, the equipment will be mounted on shock isolation platforms. The design will include, where feasible, certain features which will enhance the survivability of the piping systems. For example, double suction pumps are more likely to withstand shock forces generated by ground motion with the impeller supported on both sides. Conversely, pumps with overhung impellers should not be used in C4ISR installations unless they are mounted on shock isolated platforms.

8-3. Specifications

Guide specifications which are issued and approved by the DOD components shall be used in the procurement of piping systems, heating, ventilating, and air conditioning (HVAC) systems, and mechanical systems for new facilities and processes, as well as modernization, renovation, and repair work on existing facilities.

8-4. Cooling water systems

When cooling water is required, it shall be derived from cooling towers, radiators, heat exchangers, wells, or natural water sources and at least one redundant feed source shall be provided. The cooling source reliability and availability, rather than economics shall determine the system to be used. The facilities tactical operating scenario will determine the cooling water system configuration. Design cooling water systems to meet the requirements of American National Standards Institute (ANSI) B31.3, Code for Pressure Piping, Chemical Plant, and Petroleum Refinery Piping, for ordinary fluids.

a. A means will be provided for transferring the waste heat from the facilities cooling equipment either to the atmosphere, via cooling towers, radiators, heat exchangers etc., or to a hardened heat sink as directed by the commander or the director of public works (DPW). The vulnerability to attack surface cooling water sources such as a river, pond, or shallow aquifer may require a hardened facility to include cooling media storage that is available throughout the attack period. Design guidance for hardened facility heat sinks shall be in accordance with TM 5-855-4, Heating Ventilating, and Air Conditioning of Hardened Installations.

b. The cooling tower circulating water systems for C4ISR facilities will generally be of a closed-loop design utilizing cooling towers, storage tanks, basins, pumps, filters, heat exchangers, and water treatment facilities. The cooling towers will be surface mounted or protected below grade if required to escape a blast wave. The exterior cooling water shall be protected from freezing during periods of cold weather. Figure 8-2 shows a typical cooling water flow system for diesel generators using heat exchanger cooling.

c. Liquid-cooled diesel generators shall be arranged for closed-loop cooling and shall consist of one of the following: a unit-mounted radiator and fan; a remote radiator cooling system; or a heat exchanger (liquid-to-liquid) cooling system. Cooling systems shall prevent overheating of prime movers under conditions of highest anticipated ambient temperature at the install elevation when fully loaded. A full load on-site test shall not result in activation of a high temperature alarm or high temperature shutdown. The generator engines shall be equipped with automatic high temperature protection and shutdown. Power for fans and pumps on remote radiators and heat exchanger cooling systems shall be supplied from the diesel generators upon loss of commercial power. On emergency generator cooling systems requiring intermittent or continuous waterflow, pressure, or both, a utility or city water supply service shall not be used as the cooling source. It shall be permitted to use utility or city water for filling or makeup water if the source is reliable and is approved by the DPW.

d. A finned-coil heat exchanger (i.e., radiator) exposed directly to the ambient air may be used aboveground or in a buried chamber to dissipate heat generated by the diesel generator prime movers. An underground radiator that utilizes auxiliary fans to draw (or force) cooling air from the outside through the coil and exhaust the rejected heat to the outside offers a greater degree of protection against the elements (dust or sandstorms) and weapon effects but requires more fan horse-power for air movement. Blast closure devices, debris shields, and dirt traps in the supply and exhaust ducts will increase the level of protection. Generator vaults will have provisions to wash down the radiators and pump out material deposited on the coil surfaces.

e. Cooling towers will generally be cylindrical and constructed of reinforced concrete to resist severe shock loading on aboveground tower structure, including all internals of the tower. Towers with the potential for exposure to direct thermal radiation will have critical parts of the system shielded from this effect. Where cooling towers are required to operate in extreme winter conditions, provision will be made to prevent freezing and ice buildup on the tower. Cooling tower makeup water used during normal operation will be from the domestic water supply or from wells located on the site. Consideration will be given to using hardened storage tanks or hardened wells to provide cooling tower makeup if required for the post-attack period. All pumps installed in the cooling tower circulating water system will be inherently capable of withstanding ground shock or will be dynamically mounted to reduce the shock to an acceptable level.

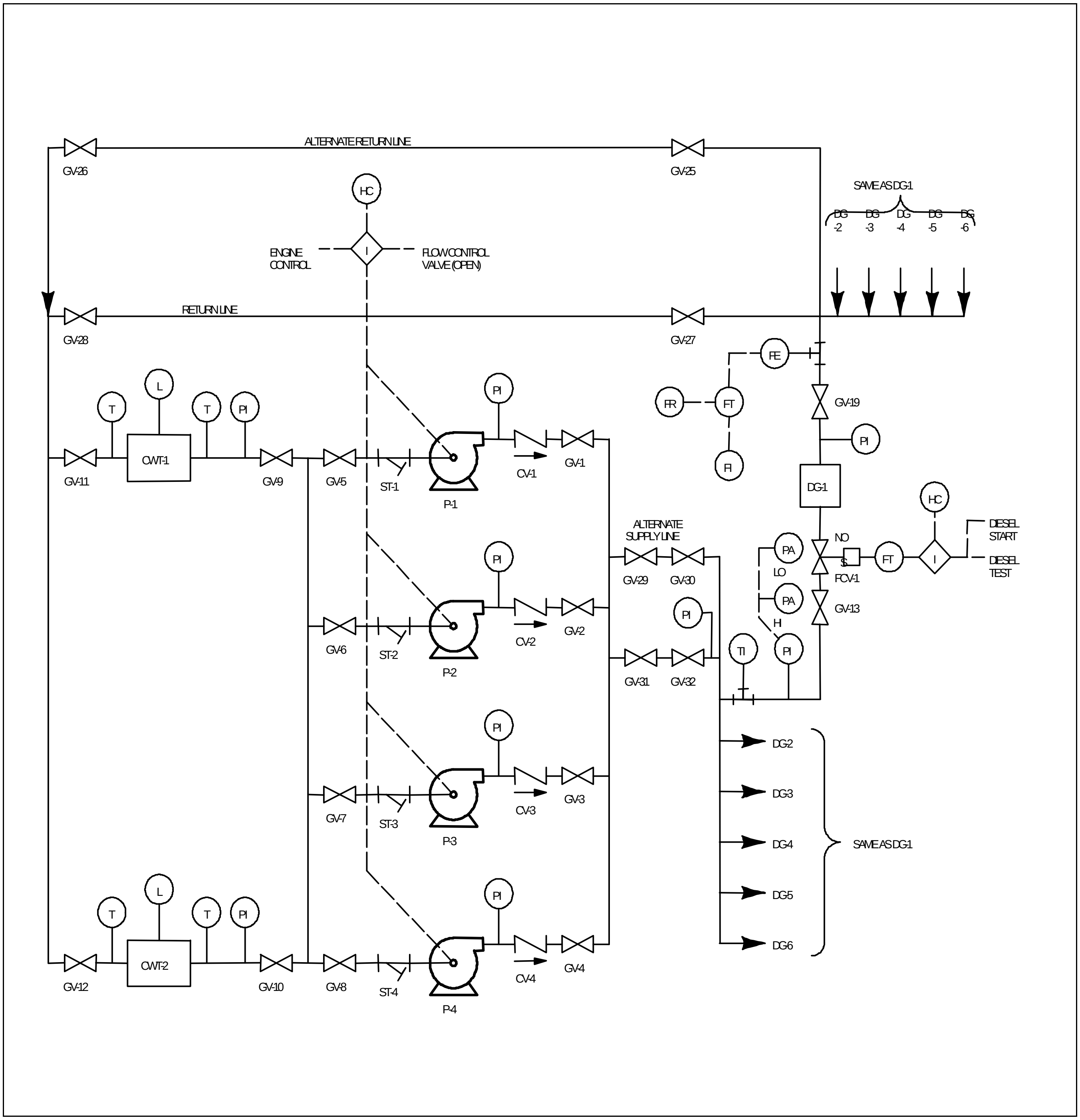

Figure 8-2. Typical cooling water flow & instrumentation diagram

f. Condenser water for mission critical chillers shall be supplied from a dedicated tower and cooling water system. Condenser water systems and cooling towers for non-mission critical HVAC chillers will be separate from the mission critical cooling water systems. If the supply of condenser water for the mission critical chillers is drawn from underground wells or reservoirs, the chemical content of this water must be analyzed to determine the fouling factor. The fouling factor must be considered in the condenser design and in determining the requirements for water treatment equipment in the system. Provide appropriate filtration/strainers to preclude plugging of service lines. Consider blending and bypass systems for the return water loop for severe cold weather conditions.

g. Where possible, cooling water systems shall be selected and designed to avoid once-through cooling as the primary cooling means in order to conserve water and to minimize industrial wastewater. When operating conditions require the use of once-through cooling water, the following requirements must be included in the design.

(1) All once-through cooling water must be supplied from a process water source with appropriate backflow prevention.

(2) Once-through cooling water discharges planned for the sanitary sewer system or the storm sewer system must be approved by the appropriate site environmental organizations and the DPW.

(3) All discharges planned and approved for the storm sewer system must be treated at the source to reduce the residual chlorine content to the allowable site levels.

8-5. Fuel systems

The main components of a diesel fuel system consist of the main storage tanks, transfer pumps, day tanks, fuel injection pumps, fuel injection nozzles, and filters and strainers. The design of these components should be in accordance with recommendations of the engine manufacturer for optimum performance and warranty protection.

a. Fuel storage capacity shall be divided equally between two main storage tanks when bulk storage facilities are not available. Transfer capabilities between the tanks shall be provided. A recirculation system shall be provided in the tanks. A means shall be provided to inhibit growth of bacteria in the main tanks. Duplex filter separators shall be installed at the inlet to the main storage tanks and each day tank.

(1) Each diesel generator set shall have one day tank. The capacity of day tanks shall not exceed the maximum allowed by National Fire Protection Association (NFPA) 37, Stationary Combustion Engines and Gas Turbines. All day tanks shall be manifold together and automatically filled to a constant level. Pumps and automatic valves shall be interlockable to remotely shut off fuel to a unit when any of its fire protection systems are activated. Flame arrestors shall be provided on fuel storage tanks when required by NFPA 30, Flammable and Combustible Liquids Code. See figure 8-3 for a typical diesel fuel flow and instrumentation diagram.

(2) Liquid fuel for auxiliary power generating systems is usually stored in buried tanks equipped with vent pipes and manholes. Aboveground tanks may be used for storage at some locations. These tanks usually have provisions for venting, filling, and cleaning. A minimum of two fuel storage tanks is necessary to ensure redundancy and to allow tank cleaning (every two years) and maintenance operations. Storage tanks should allow for checking of settled water accumulation due to condensation and should allow for provisions to remove free water.

(3) Day tanks are normally filled by transfer pumps from the installation’s main storage tanks. Provisions should be made to fill the day tanks by alternate means (or directly from safety cans or barrels) if the transfer system fails.

b. The minimum supply of backup fuel will be determined by the installation DPW. Local conditions and availability of fuels for emergency situations will be the criteria used to determine the quantities required for on-site storage. The fuel supplies for the emergency generators shall not be used for any other purpose.

c. Main fuel supply tanks located outside aboveground or underground, or beneath a structure, shall comply with the applicable provisions of NFPA 30. Facilities shall be provided for storage tanks in accordance with NFPA 30 so that any accidental discharge of liquids will be prevented from endangering important facilities and adjoining property, or reaching waterways. The type and grade of fuel shall be identified on the fuel storage tanks.

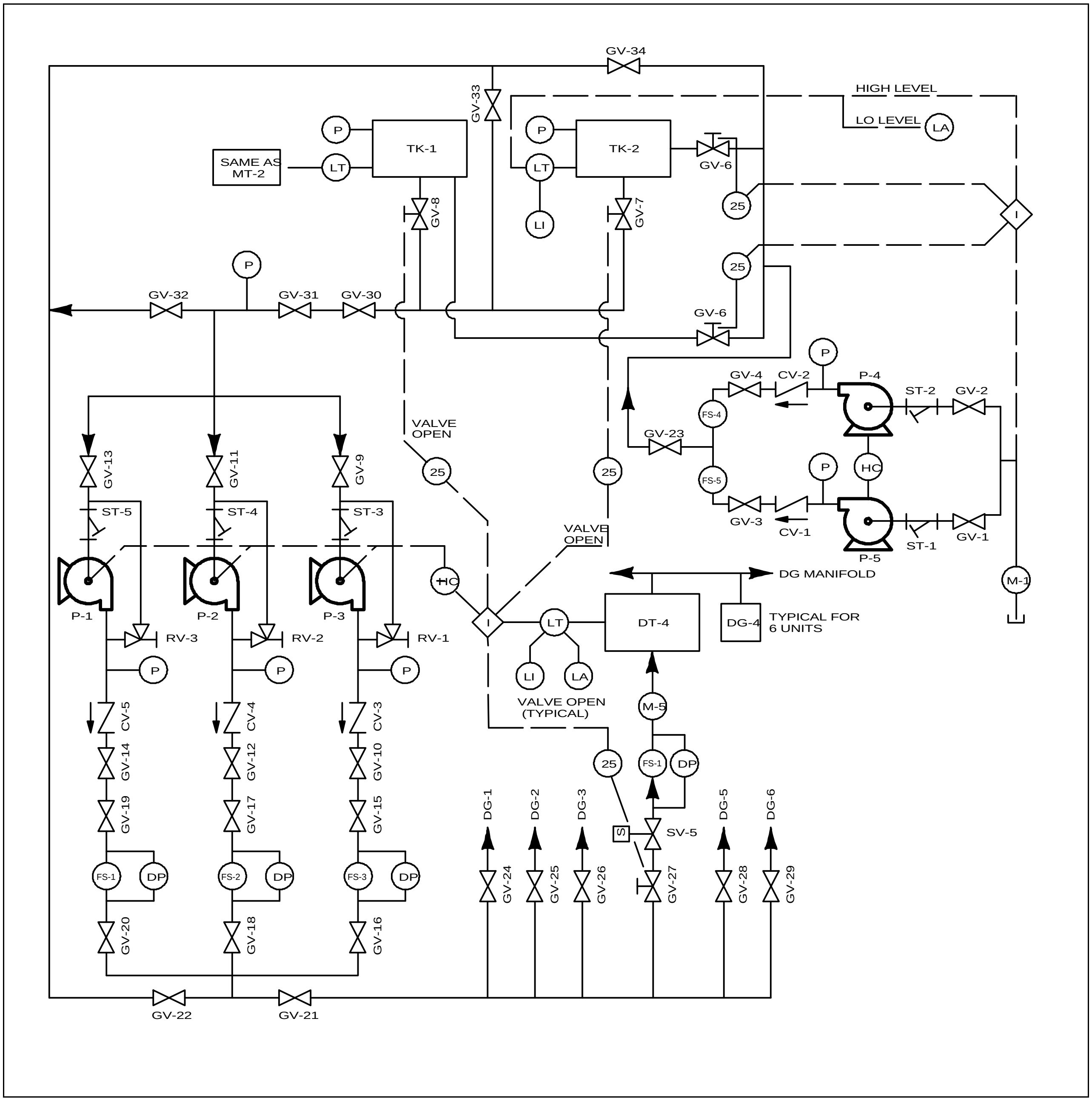

Figure 8-3. Typical diesel fuel flow & instrumentation diagram

d. Underground fuel tanks and piping shall comply with 40 CFR 280, Underground Storage Tanks, and NFPA 30. All underground tanks shall be set on firm foundations and surrounded with at least 6 inches of noncorrosive inert material such as clean sand or gravel well tamped in place. Underground fuel storage tanks and their piping systems shall be double wall construction and shall be protected by a properly engineered, installed, and maintained cathodic protection system in accordance with recognized standards of design. The AHJ may waive the requirements for corrosion protection where evidence is provided that such protection is not necessary.

e. Outside aboveground fuel supply tanks shall be constructed in accordance with the applicable tank specification in NFPA 30. Secondary containment diking shall be around aboveground fuel storage tanks. The volumetric capacity of the diked area shall not be less than the greatest amount of liquid that can be released from the largest tank within the diked area, assuming a full tank.

f. Not more than one integral tank shall be installed on each engine. It shall be securely mounted on the engine assembly, protected against vibration, physical damage, engine heat, and the heat of exhaust piping. Unenclosed day tanks (i.e., tanks not in a room by themselves) supplying engines that drive generators or other equipment used for emergency purposes shall not exceed 660 gallons. Not more than one unenclosed tank shall be connected to one engine. The aggregate capacity of all unenclosed day and supply tanks in a building shall not exceed 1,320 gallons. Day tanks on diesel systems shall be installed in accordance with the manufacturer's instructions based on whether the day tank is above or below the main storage tanks. All day tanks shall be manifold together and automatically filled to a constant level. Gravity fuel return lines shall be sized to handle the potential fuel flow and shall be free of traps so that fuel can flow freely to the day tank or main tank. Quantities of all types of fuels stored in buildings shall meet applicable requirements of NFPA 30, 37, and the AHJ. Day tanks shall be of steel with welded joints. Diking shall be provided in the generator equipment room to contain the largest potential spill from the day tanks. Or a drainage system shall be provided for the generator room that is adequate in size and location to convey any spillage of fuel to a storage tank (inside or outside) or to a safe and approved location outside the structure. Listed generator subbase secondary containment fuel tanks of 660 gallon capacity and below shall be permitted to be installed indoors without diking or remote impounding. A minimum clearance of 3 feet shall be maintained on all sides. The type and grade of fuel shall be identified on the day tanks or integral.

g. Piping and vents for day, integral, and supply tanks shall be in accordance with NFPA 30. Integral and day tanks for diesel generators shall be filled by a closed piping system except when filling from a container when the engine is shut down. Galvanized fuel lines shall not be used. Fuel piping shall be steel. Fuel lines in the generator room are typically located in floor trenches that are covered with removable non-skid steel plates. Trenches are sloped to collection sumps. Approved flexible fuel lines shall be used between the prime mover and the fuel piping for protection against damage caused by settlement, vibration, expansion, contraction, or corrosion. Piping systems shall be substantially supported and protected against physical damage and excessive stresses. Overflows, vents, fuel piping, or fuel tanks shall not be located at or near engine air intake, exhaust piping, mufflers, or filters.

(1) Fuel storage tanks shall be properly sized with vent and fill pipes located to prevent entry of groundwater or rain into the fuel tank. Piping to aboveground fuel storage tanks filled from tank cars or tank vehicles by centrifugal pumps shall be provided with check valves to prevent backflow. Each storage tank should have drain valves for removal of bottom water.

(2) Liquid fuel shall be fed from the day tank to the diesel engine by the engine fuel pump. When the main fuel storage tank is below the elevation of the day tank, a fuel transfer pump shall be installed as close as possible to the supply tank to pump fuel from the supply tank to the day tank.

(3) Day tanks or integral tanks shall be provided with an overflow line or fuel return line in accordance with manufacturer's instructions, a high level alarm, and a high level automatic shutoff. The overflow and fuel return line(s) shall be continuous piping without valves or traps. Capacity shall exceed the delivery capacity of the supply lines.

h. A low-fuel sensing switch shall be provided for the main fuel supply tanks and day tanks. Fuel transfer pumps supplying integral or day tanks shall have stop controls sensitive to a tank's high liquid level.

(1) Fuel in underground storage tanks can be measured by immersing a calibrated dip stick in the tanks. For day tanks, a glass sight gauge or a float actuated gauge can be used to measure the quantity of liquid fuel. Remote indication of the fuel levels in the storage tanks and day tanks shall be provided at the control room.

(2) Sufficient valves shall be provided to control flow of liquid fuel in normal operation and to shut off the flow of fuel in the event of a pipe break. Where used, solenoid valves, both in the fuel line from the supply tank(s) to the generator set and in the water-cooling lines, shall operate from battery voltage. Means shall be provided for manual (nonelectric) operation of these solenoid valves, or a manual bypass valve shall be provided. The manual bypass valve shall be visible and accessible and its purpose identified. This fuel valve shall not be the valve used for malfunction or emergency shutdown.

8-6. Air start systems

Some larger diesel engines may use an air starting motor instead of an electric battery starting system. The use of air starting systems shall be permitted where recommended by the manufacturer of the prime mover, subject to approval of the AHJ. Pneumatic air starter motors are highly reliable. Air starting motors are suitable on diesel generators ranging from about 85 kW up to the largest diesel engine generators. Air starting motors should be supplied from the generator manufacturer with the engine. See figure 8-4 for a typical starting airflow and instrumentation diagram.

a. Air starter motors develop enough torque to spin the engine at twice the cranking speed in half the time required by electric starter motors. Compressed air at a pressure of 110 to 250 psi is stored in storage tanks, regulated to 110 psi, and piped to the air starting motors. Appropriate allowances must be made for pressure drops in the air distribution lines.

b. A check valve installed between the compressor and the storage tanks will prevent depletion of compressed air should the air system fail. Air compressors are driven by electric motors wired to the emergency power source (i.e., diesel generators) with back-up gasoline driven engines for added starting protection. For large central station air supply systems with an abundance of air receiver capacity, a gasoline driven backup motor for the air compressor may not be necessary.

c. Air starting motor supply piping should be short, direct, and at least equal in size to the air motor intake opening. Steel piping is preferable and should be supported to avoid stresses on the compressor. Flexible connections between air motor and piping are required. Deposits of oil-water mixtures accumulating in receiver tanks and piping are removed by traps. Lines shall slope toward these traps installed at intervals in the lines.

d. Air cranking systems may freeze at low ambient temperatures since water vapor in the compressed air may freeze during expansion in temperatures below 0^{o}C (32^{o}F). Therefore, components of the air starting systems should be located with heated mechanical equipment rooms to minimize the potential for freezing. The use of an air dryer or a small quantity of alcohol in the starter air tanks can also help prevent freezing.

e. Air receivers shall meet American Society of Mechanical Engineers (ASME) pressure vessel requirements and be equipped with a safety valve and pressure gauge. Air starting receivers shall be sized in accordance with requirements of the diesel generator and air starting motor manufacturers.

f. Air starting receivers shall be sized for the specified number of starting attempts and crank duration as specified in NFPA 110, Emergency and Standby Power Systems. Diesel prime movers shall be permitted to use continuous cranking methods. Upon starting and running the diesel prime mover, further cranking shall cease. Two means of cranking termination shall be utilized so that one serves as backup to prevent inadvertent starter engagement.

g. Thermostatically controlled jacket water heaters shall be used to reduce cranking time and promote more dependable starts.

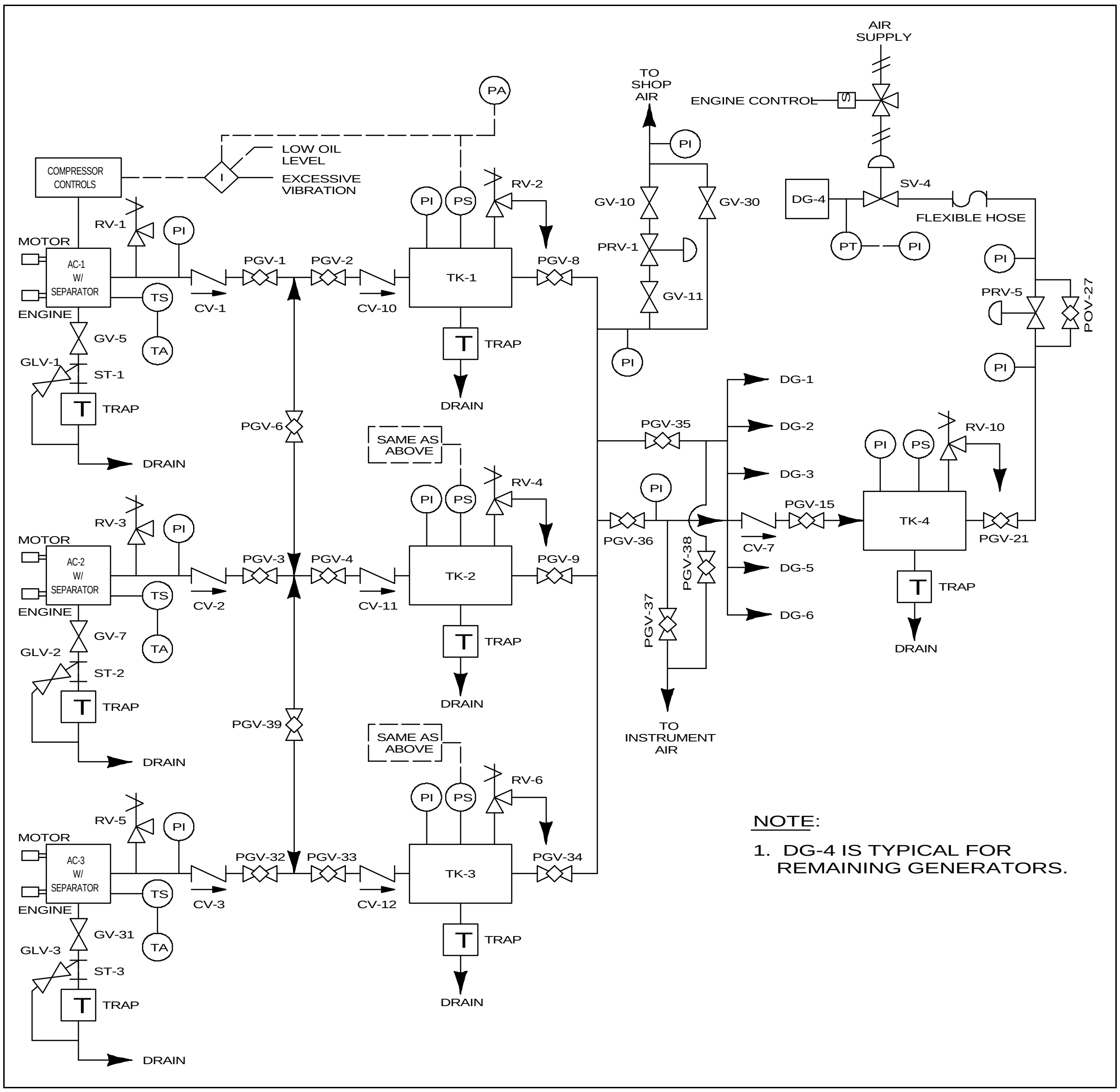

Figure 8-4. Typical starting air flow & instrumentation diagram

8-7. Instrument air systems

Design guidance for the design of low pressure instrument air systems with a maximum design operating pressure of 125 psig shall be in accordance with TM 5-810-4, Compressed Air. Design steel and copper tubing systems to meet the requirements of ANSI B31.3. When an instrument air system is used, the instrument air receivers shall be sized to meet the maximum demand for at least one hour. The air shall be dried to a constant maximum pressure dew point of 1.7°C (35°F) or atmospheric dew point of -23.3°C (-10°F) at 7.3 kg/cm^2 (100 psig). When air is used for prime mover starting, there shall be an interconnecting emergency line from the air starting receivers to the instrument air system. Refer to figure 8-5 for a typical instrument air flow diagram.

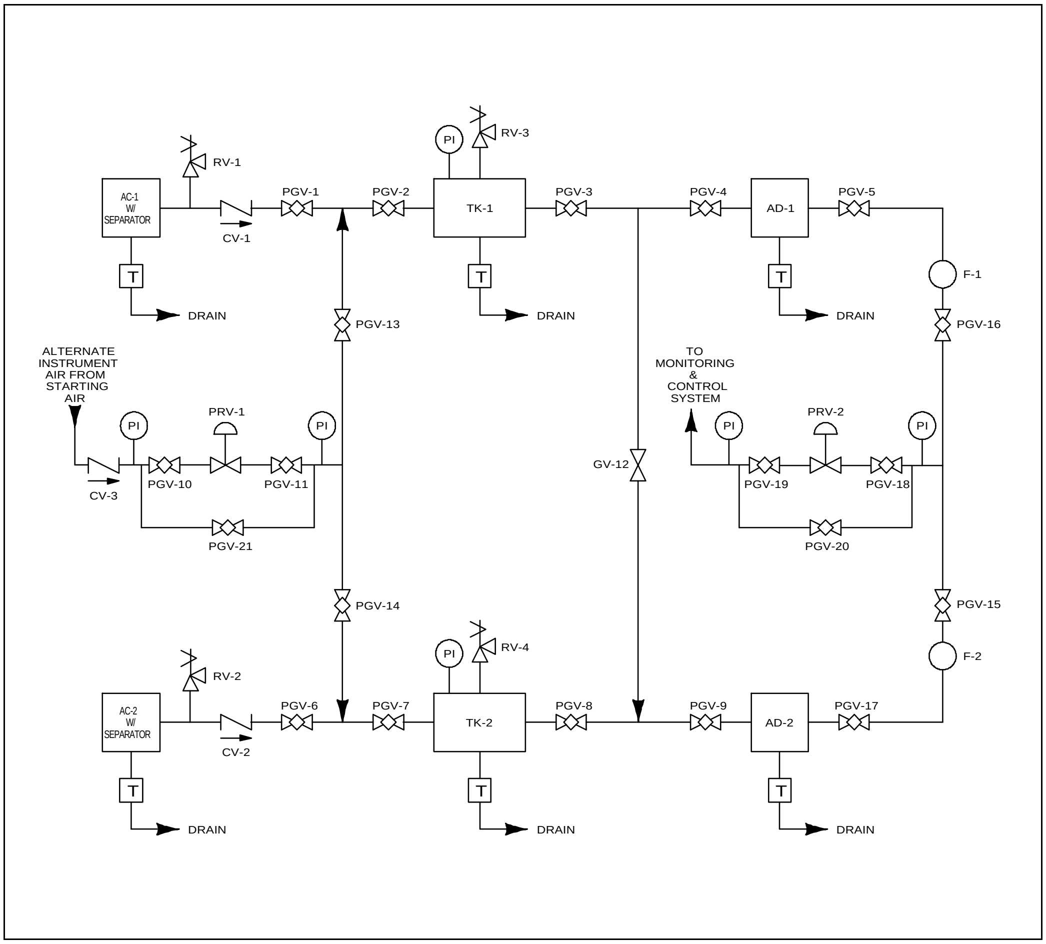

Figure 8-5. Typical instrument air flow diagram

8-8. Lube oil systems

Storage and automatic transfer facilities shall be provided for both clean and dirty lube oil. The storage shall provide for 30-day makeup requirements plus an oil change for all equipment. The tank system shall be sized to pump non-refreshed for a minimum of one hour. Crankcase or oil reservoir vents and piping shall be in accordance with NFPA 37.

8-9. Water treatment

Treatment of cooling water systems, potable water supplies, and wastewater effluent shall be in accordance with the following criteria.

a. Water treatment equipment and facilities shall be provided to protect the cooling water system against such damaging effects as corrosion, inorganic scaling, and organic growths. Installation of nonchemical devices such as magnetic, electromagnetic, and similar devices that claim to soften water or reduce scale in water systems, heating and cooling systems, or boilers are prohibited.

b. Installation commanders will provide facilities to disinfect water supplies in accordance with TM 5-660, Maintenance and Operation of Water Supply, Treatment and Distribution Systems. In coordination with the Installation Medical Authority (IMA), the DPW will disinfect new and repaired water mains, storage tanks, wells, and equipment in accordance with American waterworks Association (AWWA) C651, Disinfecting Water Mains; AWWA C652, Disinfection of Water-Storage Facilities; AWWA C653, Disinfection of Water Treatment Plants; and AWWA C654, Disinfection of Wells, following construction, repairs, installation of taps, or contamination situations.

c. Whenever possible, wastewater effluent should be sent to a suitable treatment plant which can treat the effluent to meet National Pollutant Discharge Elimination System (NPDES) permit requirements.

8-10. Corrosion protection

Protect underground piping against corrosion either by the use of resistant materials or other protective measures. Use naturally resistant materials when adequate protection is provided by their use. Site soil and groundwater conditions (e.g., soil corrosivity) shall be considered during the selection of the corrosion protection system(s).

a. Metallic water supply and metallic wastewater collection lines should be bonded and coated. External surfaces that are in contact with soil and all internal surfaces of steel water storage tanks should be protected from corrosion by a cathodic protection system.

b. If buried fuel systems require cathodic protection, the protection system shall be installed at the same time as the pipeline. Design piping system to reflect the special requirements of cathodic protected systems addressed in chapter 10, Electrical Systems. Install adequate test stations to evaluate the performance of the cathodic protection system after installation. Terminate test stations aboveground in accordance with chapter 10, Electrical Systems. Connection at joints shall ensure electrical continuity except where insulating joints are installed. Insulating joints shall be used to electrically isolate protected sections from non-protected sections and from neighboring metallic structures. Where ferrous pipe is installed within the distribution system, insulating couplings shall be installed to preclude galvanic corrosion. Cathodic protection for underground flammable/combustible liquid storage tanks shall comply with NFPA 30. Coordinate the type of cathodic protection required with the electrical design.

8-11. Protection

Piping penetrations through shielded mission critical areas should be protected properly to avoid degrading the electromagnetic pulse (EMP) shielding effectiveness.

a. Three types of piping penetrations need to be considered:

(1) A metallic pipe that carries a conducting fluid (e.g., steel chilled water pipe)

(2) A metallic pipe carrying a dielectric fluid (e.g., steel air pipe)

(3) A dielectric pipe carrying a dielectric fluid (e.g., plastic air hose)

b. A fourth possibility, a conducting fluid in a dielectric pipe (or dielectrically lined metal pipe such as glass-lined steel) cannot be EMP protected properly and must be avoided.

c. The waveguide-beyond-cutoff principle is used for piping penetrations. For a metal pipe, a circumferential weld to the primary shield is required so that current flowing in/on the pipe can be discharged onto the outer surface of the shield. The interior pipe wall serves as the waveguide. The inside diameter (d) should be less than or equal to 4 inches to provide a cutoff frequency of 1.73 GHz. The continuous length (l) adjacent to the penetration must be a minimum of five diameters to attenuate by at least 100 dB at the required frequencies. If a pipe is greater than 4 inches, inside diameter is required and protection options include:

(1) Subdivide into two (or more) pipes that satisfy the dimensional requirements.

(2) Insert a honeycomb filter inside the pipe and treat the penetration as described for air distribution penetrations. If this method is used, the higher pressure drops incurred must be taken into account when sizing the chilled water pumps.

d. If a dielectric pipe with dielectric fluid penetrates through a metal waveguide sleeve, the sleeve has the same dimensional requirements that apply to metallic pipe. It is common practice to fill the waveguide sleeve with epoxy or similar material to prevent the insertion of conductors (e.g., conducting fluids, wires, pull wires). Dielectric pipes greater than 4-inch inside diameter follow the same guidelines as metal pipes greater than 4 inches as discussed above.

e. Controls for motorized valves, pump motor controls, and pressure and flow sensors, etc., must be protected to ensure their operation during an EMP event. The basic protection method is to surround the controls with a separately grounded conducting barrier.

8-12. Water distribution system

This paragraph covers the utility water distribution system, piping downstream of the water treatment plants, cooling towers, and mechanical chiller equipment excluding fire protection systems which is covered in chapter 6, Fire Protection Systems. Requirements for trenching and for routing and burial of underground pipelines is defined in chapter 4, Civil and Site Engineering and Waste Management.

a. Size water lines using the Darcy-Weisbach formula by extracting data from the Moody diagrams for friction losses in water pipe.

b. Water mains shall be designed in accordance with the following criteria:

(1) Design the distribution system to use the looped-grid type system providing two-way flow with sectional valving arranged to provide alternate water flow paths to any point in the system.

(2) Design water system to meet requirements of the National Standard Plumbing Code or other building code applicable to the region.

(3) Design water mains supplying fire protection systems and fire hydrants to meet further requirements of NFPA 24, Private Fire Service Mains.

(4) Design water mains to maintain a normal operating pressure range of 40 to 100 psi in distribution mains and building service lines. Design mains for a minimum pressure rating of 150 psi.

(5) Design system to maintain adequate residual pressure for proper operation of internal fire protection systems (sprinklers, etc.).

(6) Where service lines enter the building, provide suitable flexibility to protect against differential settlement or seismic activity in accordance with the National Standard Plumbing Code or NFPA 13, Installation of Sprinkler Systems.

(7) Building service lines larger than 2 inches in diameter shall be connected to the distribution main by a rigid connection and shall have a post induction valve (PIV) located below frost line. Risers from frost line to floor lines of building shall be adequately insulated.

(8) Distribution system mains shall have a minimum depth of cover below the frost line. Additional cover or protection shall be provided at railway crossings and in high traffic areas.

c. Potable water mains shall be designed in accordance with the following criteria.

(1) Locate potable water lines in separate trench from sewer lines. Avoid routing lines under pavement (except at road crossings) or other inaccessible locations.

(2) Where feasible, potable water lines shall not be routed within 10 feet of sewers or force mains.

(3) Where potable water mains must cross sewers or force mains, water mains shall pass 2 feet above the sewer or force mains. Where insufficient cover precludes such vertical separation, the sewer or force main shall be ductile iron pipe or shall be fully encased in concrete for a minimum distance of 10 feet to each side of the water line crossing. Where feasible, sewer or force main pipe joints shall not be located within 3 feet of such crossing unless the joint is encased in concrete.

(4) Design the distribution system to deliver peak potable flow of 2 1/2 times the average daily demand plus any special demands, at a minimum residual pressure of 30 psig at ground elevation.

(5) Design potable water heaters that also serve fire protection requirements to satisfy fire protection requirements plus 50 percent of the average potable water requirements plus any process demands that cannot be reduced during a fire.

(6) Use no lead solder for copper piping in potable water systems.

d. Install reduced pressure type backflow preventer (RPTBP) or other approved device at branch lines supplying process water systems. Locate backflow preventer within 5 feet of floor level. Design to prevent cross connections between potable water and all other systems, either liquid or gas.

e. The following valves and accessories shall be included in the design of the water distribution system.

(1) Provide accessible shut-off valves at branches serving floors or multiple fixture arrangements, at risers serving multiple floors, and at equipment or appurtenances.

(2) Design combined fire water and potable water supplies to each building with valving that permits potable water system shutdown without affecting the fire water system.

(3) Use of pressure relief and surge relief valves shall be considered to preclude system damage from water hammer.

(4) Provide manufactured water hammer arresters where necessary.

(5) Install air release and vacuum valves at high points and in long supply mains.

(6) Provide a vacuum breaker at all hose connections on potable water system.

(7) Provide stop valves at each plumbing fixture.

(8) Provide drain valves to drain the plumbing system. Provide manual air vents at high points in the system.

(9) Provide ASME code-stamped tanks for hot water generation equipment when of sufficient capacity, water temperature, or heat input rate to be within the jurisdiction of the ASME Boiler and Pressure Vessel Code, Section VIII. Provide ASME-approved relief devices on hot water tanks.

(10) Provide fail-safe pressure balance type tempering valves (anti-scald) where required for personnel protection.

(11) Provide anti-sweat insulation for cold water lines inside buildings. Provide insulation for hot water lines inside buildings when required for heat conservation or personnel protection.

8-13. Potable (domestic) water supply

Potable water is defined as water that has been treated so that it may be used for drinking, personal, or culinary purposes. Effluent from the water treatment plant is pumped to storage tanks and distributed through headers to usage points. Design potable water system to comply with 40 CFR 141, National Primary Drinking Water Regulations.

a. The design shall be based on a limited-water site. There shall be sufficient on-site water (e.g., storage tanks or well) to supply critical systems for a period of 7 days minimum. Larger storage may be required if estimated supply system downtime is greater. The domestic water supply shall be used for lavatories, mechanic's and janitorial sinks, and drinking fountains. The system shall supply water to the hot water system, water treatment equipment, chilled water system, and water make-up piping. A domestic hot water system shall be provided.

b. Water from the supply source shall flow into a hydro-pneumatic tank rated for a pressure sufficient to overcome pressure losses in distribution plumbing and to maintain approximately 2.8 kg/cm^2 (40 psig) at any outlet. This tank shall supply the domestic water plumbing system. A domestic hot water storage tank shall be provided.

8-14. Eye washes and safety showers

Eye wash and safety shower water is a special use of potable water that is supplied through an independent header system. Safety shower water has special valves to prevent inadvertent disabling of the system.

a. Design safety shower system to feed off potable water supply upstream of building shutoff valve. Install locked-shield type valves, which can be locked in the open position, or other lockable type valves in the safety shower supply water lines. Type K copper shall be used for belowgrade potable water supply distribution for 2 inches and less and ductile iron shall be used for sizes larger than 2 inches based on the

Standard Plumbing Code. Emergency eyewashes, showers, or combination eyewash showers shall be provided in areas where corrosive or other skin- or eye-irritant chemicals are stored, handled, used, or dispensed. Provide safety showers, eyewash, or combination units in accordance with ANSI Z358.1, Emergency Eyewash and Shower Equipment, and 29 CFR 1910.151.c., Occupational Safety and Health Administration (OSHA).

b. Eye wash fountains and emergency safety showers shall be included in the battery room, the diesel generator room, and maintenance areas.

8-15. Process water supply

Process water is defined as water supplied from the potable water system downstream of a RPTBP approved by the University of Southern California, Foundation of Cross Connection Control and Hydraulic Research or downstream of other approved devices. Do not use process water for any personal or culinary use. Process water systems are once-through or total consumption-type systems. Identify each use point supplied by process water downstream of a vacuum breaker by signs meeting OSHA requirements. Design, operation, and maintenance of cross-connection control components (i.e., backflow prevention devices) will be in accordance with TM 5-660. A process water hose bib shall be provided in the generator equipment room for wash down of floors and equipment.

8-16. Plumbing and sanitary sewer systems

Guidance for the design of plumbing systems, together with the criteria for selecting plumbing materials, fixtures, and equipment shall be in accordance with TM 5-810-5, Plumbing. The plumbing system shall provide adequate water drainage for the fire protection systems serving mission critical, computer, and electronic equipment areas.

a. Sanitary drains convey human waste products, shower discharges, wash water waste products, and other liquids that require treatment in a sewage plant before discharge to a receiving stream. The sanitary sewer systems shall be capable of handling domestic sanitary sewage for the facility. All proposed connections to the sanitary sewer system shall be approved by the appropriate site environmental compliance organization.

b. Design the sanitary drain system to be as simple and direct as possible. Provide for known future expansion. Sanitary sewer drains shall not be connected to the storm drain system. Drains from safety showers shall be contained or collected as appropriate on each project. Where feasible, do not route sewers and force mains under buildings or other permanent structures.

c. Sewage lift stations and force mains shall not be used unless approved by the cognizant DOD authority. Sewers and force mains shall be sized to accommodate the estimated daily and maximum discharges for the initial and final years of the design period. Hydraulic design of wastewater collection systems shall comply with TM 5-814-1, Sanitary and Industrial Wastewater Collection, Gravity Sewers and Appurtenances, and TM 5-814-2, Sanitary and Industrial Wastewater Collection-Pumping Stations and Force Mains. All wastewater collection systems shall be designed for gravity flow unless such systems are not economically feasible. Design sanitary sewer system for velocities as listed in chapter 4.

8-17. Storm and process drains

This section covers piping for storm and process drains located within the building structure. Civil and Site Engineering and Waste Management, chapter 4, has responsibility for all exterior gravity drains (i.e., sanitary and storm drains) and wastewater treatment systems.

a. Storm drains convey rainwater or other liquids that do not require treatment before discharge to receiving stream. All proposed drain connections to the storm drain system shall be approved by the appropriate site environmental compliance organization. Design storm drain lines to meet the requirements of National Standard Plumbing Code.

b. Chemical or process drains convey liquids that cannot be discharged into either sanitary or storm systems without further waste water treatment. Design stainless steel chemical drains to meet the requirements of ANSI B31.3. Design drain lines for gravity flow where economically feasible. Provide clean outs in stainless steel gravity flow drain lines similar to those required by the plumbing code for cast iron (CI) drains.

8-18. Condensate drains

A waste disposal piping system shall be provided for condensate drains from air compressors, air-conditioning equipment, and similar overflow, bleed, and drain connections. These wastes shall flow through oil-water separation devices prior to entering the site sanitary sewer system.

8-19. Cooling tower blow down and drains

The blow down from cooling towers shall be piped into the site storm drain system if chlorine and chemical contamination levels are acceptable. Environmentally safe chemicals should be considered for the design of the cooling tower(s) chemical treatment systems. Cooling tower blow down shall be discharged to an appropriate wastewater or process drain system when disposal is not permitted through the facility storm drain system because of chemical contamination. Appropriate disposal of cooling tower blow down shall be approved by the site environmental organization.

8-20. Seepage and sump collection

Seepage and leakage into belowgrade structures and basements shall be collected in sump pits provided for this purpose. The leakage shall be piped into the facility storm drain system after it has passed through oil-water separation devices. Sumps and dikes shall be provided in the diesel generator room for collection of spilled oils and fuel. Sump pumps shall pump accidental spills to a wastewater treatment facility or wastewater collection system capable of safely disposing of spilled materials. Containment barriers shall be installed in sump/trench areas between the generators to prevent an oil fire from spreading the length of the power plant.

8-21. Insulation

Provide insulation of exterior aboveground and underground distribution systems and equipment for condensation prevention, minimization of energy loss, and for personnel safety. The design of insulation systems shall be based on the Thermal Insulation Manufacturers Association (TIMA) Economic Thickness Manual. Design insulation for lines subject to freezing.

a. All insulation material, media used to apply insulation, and jacketing material shall have a maximum flame spread of not more than 25 fuel-contributed and smoke-developed ratings of not over 50 when tested using Underwriters Laboratories (UL), 723, Safety Test for Surface Burning Characteristics of Building Materials. Exception to the smoke-developed rating of 50 shall be made for exterior underground piping. Asbestos or asbestos-containing materials shall not be used.

b. Specify that all insulation installed outside aboveground, in tunnels, and in manholes be provided with a metal jacket (either factory or field installed). Specify cellular rubber insulation and metal jacket for all electric traced lines and auxiliaries. Specify underground insulation considering the possibility that water infiltration will cause physical damage or loss of thermal characteristics.

8-22. Water storage tank

Steel water tanks, stand pipes, and reservoirs shall comply with NFPA 22, Water Tanks for Private Fire Protection, and American Water Works Association (AWWA) D100, Welded Steel Tanks for Water Storage.

8-23. Pressure vessels

Specify that tanks and pressure vessels qualifying by size and pressure be designed, fabricated, inspected, and stamped in accordance with the requirements of the ASME Boiler and Pressure Vessel Code, Section VIII.

8-24. Valving

Piping system valves shall be provided as noted below. All valves will be tagged with their respective valve numbers as shown on the drawings. Safety valves shall be National Board stamped and have lever operators.

a. Isolation valves shall be installed at maximum intervals of 5000 feet on long supply lines and at maximum intervals of 1200 feet on main distribution loops, feeders, and all primary branches connected to these lines.

b. Provide block valves on all service branch lines (except as prohibited herein) to maintain service during maintenance. Locate block valves for all branch headers as close as practical to the main headers. Provide block (shut off) valves at all plumbing fixtures and in all looped headers. Block valves are prohibited on relief valve lines, except for locking type allowed by the ASME code.

c. Provide check valves on all pump discharge piping.

d. Pressure-reducing valves shall be provided where service pressure or devices exceed the normal operating range recommended by the manufacturer. Whenever a pressure-reducing valve's failure may cause equipment damage or unsafe conditions, a pressure-relief valve shall be provided downstream of the reducing valve. Show type, size, pressure setting, and capacity of all pressure-reducing and relieving devices on the drawings. Design pressure relieving devices in accordance with ASME Code, Section VIII.

8-25. Piping systems maintenance

Loop piping headers where practical to provide continuous service during routine maintenance. Design consideration shall be given to providing sufficient shutoff valves to isolate equipment to facilitate maintenance and to providing drain valves for cleaning and flushing the emergency generator cooling systems. Provide working access where maintenance or replacement of equipment, valves, or other devices may be necessary.

8-26. Piping above computer and electronic equipment areas

Steam, water, or horizontal drain piping should not be in the space above the suspended ceiling and over computer and electronic equipment other than for sprinkler system use.